

Multi-Vehicle Patrolling

Objective

Our objective for this project is to create a system that will plot patrol routes for autonomous vehicles. Using our system air, ground and sea vehicles can be used to patrol Port Everglades and monitor specific user defined areas for suspicious activity making the port more secure and productive.

Requirements

- The system should take into account vehicle type (air, ground or sea).
- Patrol Routes should prioritize critical areas to monitor.
- Patrol routes should be no longer than the set energy budget for each vehicle.
- Patrol routes must be randomized to some degree so that their next action is not predictable to observers.

Patrol Area

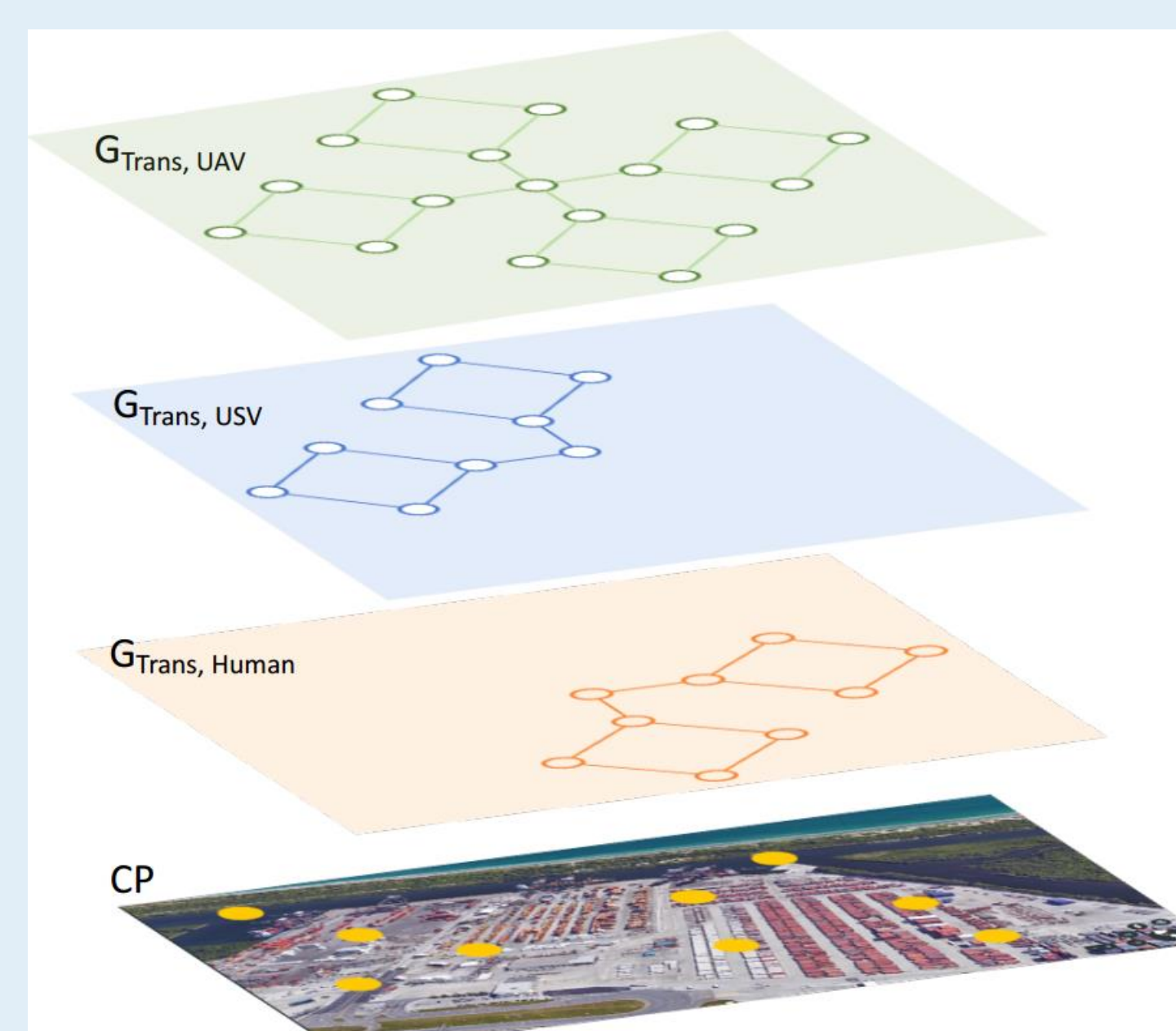


Figure 1. An illustration of critical infrastructure points from a distribution based on a survey taken by Port Everglades. The yellow points mark important areas.

Port Everglades is one of the top three cruise ports in the world, is among the most active containerized cargo ports in the United States and South Florida's main seaport for petroleum products such as gasoline and jet fuel.

As such, there are many areas that are critical for port security and productivity.

Motion Maps



A discrete network of nodes is used to represent traversable paths for each type of vehicle.

The network is overlaid on a birds-eye view of the port to show the area for which each node corresponds.

Figure 2. A visualization of how different vehicles may move through different networks of traversable nodes.

Results

The Algorithm

Algorithm 1: PATROLLINGROUTES(G, v_i, b, r)

Input: G, v_i, b, r – Motion Graph, Initial Location, Energy Budget, Visibility Range

Output: T – Set of All Patrolling Routes

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1  $C \leftarrow G.V$ 
2  $x \leftarrow v_i$ 
3  $T \leftarrow \emptyset$  // Initialize the set of patrolling routes
4 while  $C \neq \emptyset$  do
5    $P_1 \leftarrow \text{SINGLESOURCEDIJKSTRA}(G, x)$ 
6    $y \leftarrow \text{FIRSTCANDIDATE}(P_1, b, x)$ 
7    $P_2 \leftarrow \text{SINGLESOURCEDIJKSTRA}(G, y)$ 
8    $z \leftarrow \text{SECONDCANDIDATE}(P_2, b, x, y)$ 
9    $\tau \leftarrow \text{FINDROUTE}(x, y, z)$ 
10   $C \leftarrow C \setminus \{\text{VISIBLELOCATIONS}(\tau, r)\}$ 
11   $T \leftarrow T \cup \{\text{ROUTELOCATIONS}(\tau)\}$ 
12 return  $T$ 

```

The route planning algorithm creates a loop from the starting point and two other points that are near critical areas if possible.

Each segment of the loop will not exceed 1/3 of the total energy budget which guarantees that the vehicle will not exceed its energy budget.

If a loop cannot be found for any reason the vehicle will go to a single point and then return to the starting point.

Patrol Routes

After running the route planning algorithm all of the points that will be traversed and seen are recorded. All of the recorded points are plotted on top of a birds-eye view of the port for user reference (Figures 3 and 4).

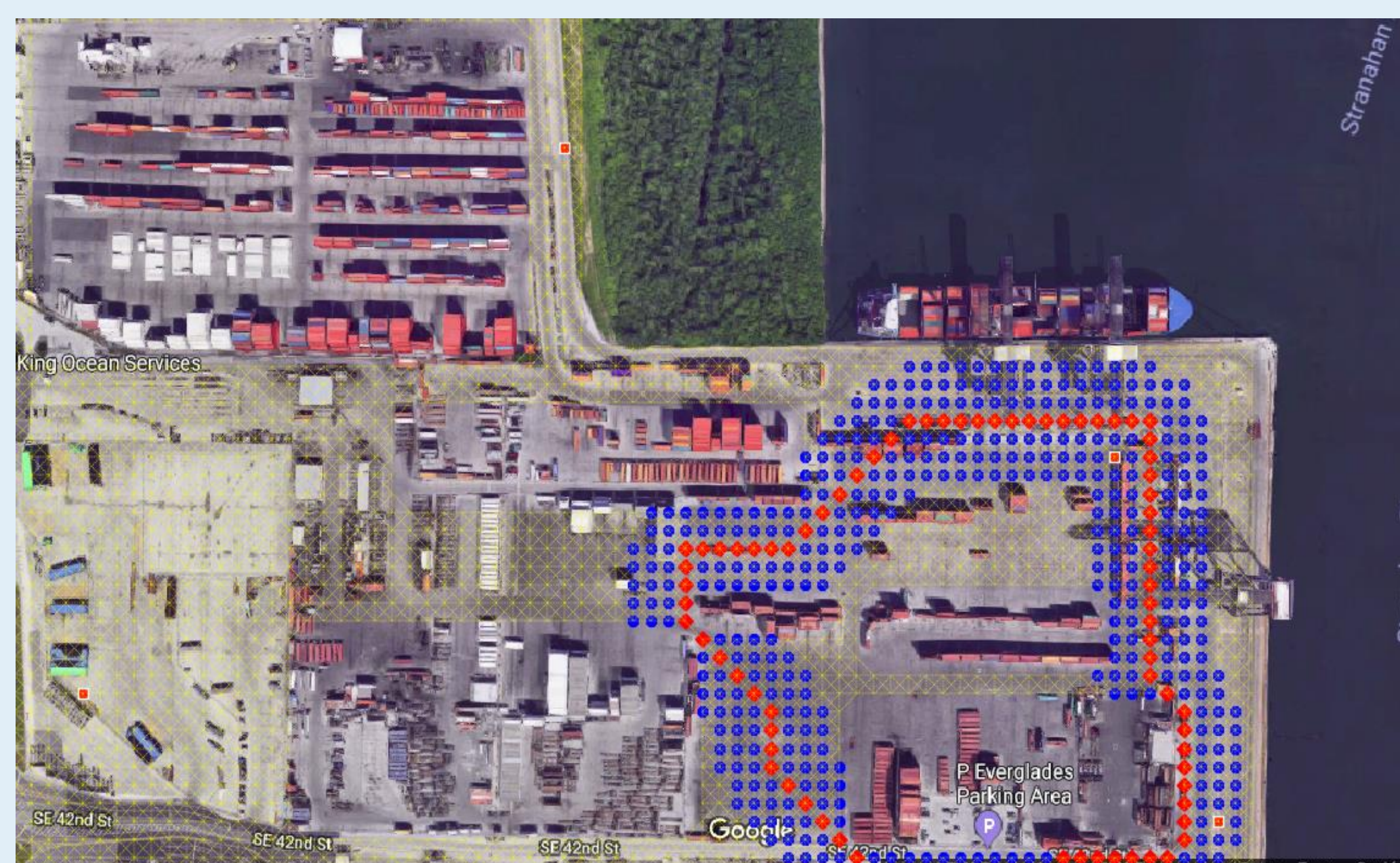


Figure 3. Shows a sample output of a route that would be taken by a ground vehicle.



Figure 4. Shows a sample output of a route that would be taken by an air vehicle.

The red points show the route taken and the blue points show the areas seen from the route. White and red nodes are critical areas that are prioritized in route generation. Note the increased visibility but smaller energy budget of the aerial vehicle compared to that of the ground vehicle.

Acknowledgements

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